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by

Zhang Wanzeng Zhang Caiyun

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I. INTRODUCTION

In the late 1960's and the early 1970's, following along with the development of such modern scientific techniques as electronics technology, information recording, as well as information transmission technologies, and so on, a type of photoelectric imagery remote sensing technology associated with a combination of traditional optical mechanics and electronics--CCD imagery remote sensing technology--quietly (illegible). This is the third leap in imagery remote sensing technology.

As far as the appearance of CCD cameras is concerned--in particular, CCD camera applications in astronavigational military reconnaissance--astronavigational imagery reconnaissance was pushed toward a new developmental stage. Due to the special characteristics and superiority of CCD cameras in and of themselves, once they were introduced to the world, they then became, therefore, an important objective pursued in the development of astronavigational reconnaissance by various space faring nations--in particular, the U.S. and the Soviet Union. For the last over ten years, development in leaps and bounds was achieved.

II. SPECIAL CHARACTERISTICS AND SUPERIORITY OF CCD CAMERAS

1. Good Efficiency

Timeliness, accuracy, and continuity are the basic factors in military intelligence. In modern conditions--particularly, in the high technology conditions of modern war--new, even higher requirements have been put forward to guarantee the operation of military reconnaissance intelligence. Speaking in a certain sense, the high speed reaction capabilities of military units are primarily dependent on the efficiency of intelligence. Using CCD cameras as digital transmission forms for reconnaissance equipment associated with imagery reconnaissance satellites, it is possible to take reconnaissance data obtained and directly transmit it back to the ground in real time or to go through data relay satellites to transmit it back to the ground. In this way, the realization of real time or close to real time reconnaissance makes the efficiency of intelligence greatly increase. Besides this, using CCD cameras as digital transmission forms for reconnaissance equipment associated with imagery reconnaissance satellites is different from returnable type visible light photography reconnaissance satellites. They do not suffer from limitations associated with signal recording carriers taken along by satellites and orbital operating life (generally, 3-5 years). It is possible to realize long orbital periods and continuous reconnaissance. If aided by orbital maneuvering technology, it is possible to make satellites possess reconnaissance capabilities associated with variable orbits and maneuvering. If camera systems adopt corresponding technological measures, it is also possible to very, very greatly shorten the reconnaissance

repetition period with respect to the same area. SPOT earth natural resources satellites are just like this. The observational repetition period is 2-3 days.

2. Abundant Amounts of Information

Occupying a commanding position, taking everything in at a glance, and making the most out of a little is one of the greatest characteristics associated with astronavigational military reconnaissance--in particular, astronaviagtional imagery reconnaissance. Imagery reconnaissance satellites are capable of obtaining imagery information associated with natural and man made topography, surface features, land forms, ships at sea, as well as various types of aerial targets within the range of the visual field. Within orbital reconnaissance coverage regions, the types and amount of information can be said to be "all embracing" and "numbering tens of thousands". Practical implementation clearly shows that, as far as using CCD cameras as digital transmission forms for reconnaissance equipment /162 associated with imagery reconnaissance satellites is concerned, the imagery information which is obtained--in particular, multiple spectrum segment imagery information--includes amounts of data far more numerous than other ordinary photographs. After making use of such things as computers and normal correlation statistical methods to carry out processing with respect to digital imagery, details of images can then appear. It is also possible to take large amounts of "invisible" information and extract it. Besides this, as far as CCD cameras are concerned, dynamic ranges associated with weather are great. With solar angles of elevation relatively low, it is possible for visibility to be comparatively bad. In situations where ordinary camera film has difficulty forming images, the system is still capable of obtaining relatively good and comparatively numerous imagery information. There will also be no appearance of phenomena associated with that type of inadequate exposure or excessive exposure of photographic film.

3. Automation with Advantages for the Realization of Intelligence

With respect to using CCD cameras as digital transmission forms for reconnaissance equipment associated with imagery reconnaissance satellites, the reconnaissance information is generally capable of undergoing processing on board the satellite in order to discard those large amounts of repetitive or "useless" information. Satellite ground stations and satellite reconnaissance information ground processing systems are also capable of being simplified a step further, making astronavigational reconnaissance systems even more appropriate for wartime use. After digital imagery information is transmited back to the ground, it is possible to directly input it into computers to carry out application of technical processing, making command, control, communications, and intelligence form an organic strategic C3I automated command system, thereby very, very greatly increasing the level of automatization associated with military units and fast reaction capabilities associated

with units.

4. High Intelligence Benefits and Economic Benefits

As far as using CCD as a digital transmission form for reconnaissance equipment associated with imagery reconnaissance satellites is concerned, operating life is long. Not only is it possible to implement continuous reconnaissance and monitoring of the globe for long periods. It is also possible to carry out "quick check" and period reconnaissance of with respect to certain "hot spot" regions of interest in order to obtain trends and continuous intelligence within the reconnaissance region. With respect to foreign transmission forms associated with imagery reconnaissance satellites, operating life is generally 3-5 years. The military intelligence benefits and economic benefits are generally several fold to over ten fold those for the same type of returnable model photographic reconnaissance satellite (Table 1).

III. DEVELOPMENT AND APPLICATIONS OF CCD CAMERAS

As far as the history of transmission type satellites is concerned, it is necessary to trace it back to the early 1960's. Their earliest ancestors are the U.S "Tailuosi (phonetic)" and "Nimbus" weather observation satellites. Using electrically charged coupling devices to act as detector CCD cameras, the pioneering application in astronavigational military reconnaissance was the "Key Hole" (KH-11) satellite launched by the U.S. in 1976. The satellite possessed relatively great reconnaissance capabilities associated with orbital change and maneuver. It was capable--based on directions from the ground--of carrying out necessary reconnaissance missions associated with certain "hot spot" regions. The application of CCD cameras in astronavigational military reconnaissance achieved success in the improved model of the U.S. KH-11--the KH-12. This is the U.S. sixth generation imagery reconnaissance satellite. The first satellite was put into orbit on 8 August 1989 by the space shuttle "Columbia". KH-12 imagery ground resolution was capable of reaching limit resolutions of 0.15m. KH-12 possessed a longer operating life than KH-11 as well as greater capabilities associated with maneuver and orbital change.

Table 1 Comparision of Satellite Photoelectric Remote Sensing Performance

(1) 国别	(2) 卫星名称	(3) 发射日期	(4) 分辨率(m)	(5) 遥感器
(6) 美国	Landsat-1	1972.07.23	79	MSS
(6) 美国	Landsat-5	1984.03.01	30	TM
(6) 美国	KH-11	1976.12.19	1.5-3	HRV
(7) 前苏联	(10) 宇宙-1426	1982.12.28	0.15	HRV
(6) 美国	KH-12	1989.08.08	0.15	HRV
(8) 法国	SPOT-1	1986.02.22	10/20	HRV(双)(9)

Key: (1) Nationality (2) Satellite Nomenclature (3) Launch Date (4) Resolution (5) Remote Sensing Device (6) U.S. (7) Former Soviet Union (8) France (9) Dual /163

On 28 December 1982, the former Soviet Union put its first digital transmission type imagery reconnaissance satellite--"Cosmos-1426"--into orbit. From December 1982 to the end of 1990, the former Soviet Union launched a total of 13 transmission type imagery satellites. Maximum operating life approached 259 days. Imagery ground resolution was estimated as being not much different from the U.S. KH-11.

CCD cameras have broad prospects for applications in global natural resources sensing and enormous development potential. In this area, the one that has been relatively successful is France's SPOT global natural resources satellite. The first SPOT satellite was launched into orbit on 22 February 1986. SPOT satellites are equiped with two CCD scanning type cameras that are the same (HRV). Systems are composed of such things as reflector mirrors, lenses, optical filters, and four module (each module is 1728 image elements) linear array electrically charged coupling devices (CCD), and so on. The optical spectrum range is 0.50-0.89μm. Satellites are in 832km high solar synchronous orbits and are capable of providing panchromatic imagery with resolutions of 10m as well as multiple optical spectrum imagery with resolutions of 20m. Initially, SPOT satellite imagery was basically designed for use in oceanic surveys, geological mineral prospecting, investigations of energy resources, estimates of crop production, ecological monitoring, and programed utilization of land, as well as the compilation and update of large scale topographical maps, and so on. After satellites had been

successfully launched and put into commercial operation--using their fast data transmission speeds--they were capable of vertical, oblique, and three dimensional observations, as well as being capable of such characteristics as revisiting--within short periods--the same area, soliciting a great many users. SPOT-1 already ceased operations on 31 December 1990. The follow on satellite, SPOT-2, was launched into orbit on 22 January 1990. The potential military applications of SPOT satellites go without saying. In acutality, they are already used by advanced nations which include the U.S. and France and a number of third world countries to collect military intelligence. During the Gulf War, SPOT satellite remote sensing imagery satisfied a pressing need for the U.S. in drawing up large scale topographical maps of the Gulf region. During this, France also made use of SPOT satellites to monitor changes in the Gulf area situation and the progress of the war.

As far as SPOT satellite launches and successful applications are concerned, they have further strengthened France's rapid deployment and promoted the determination for and pace of their military imagery reconnaissance satellite development programs. Two of France's "Helios" military imagery reconnaissance satellites will be launched in 1993. The satellites' panchromatic imagery ground resolution is 1m.

Summarizing what has been discussed above, the appearance and development of the use of CCD cameras as reconnaissance equipment for transmission type imagery reconnaissance satellites is a necessary development of science and technology under modern conditions. With respect to their introduction and application, they presage development directions and trends associated with astronavigational imagery reconnaissance and astronavigational natural resource remote sensing. The authors believe that, if, early in the next century, imagery optical spectrometers and imagery radars (SAR) will dominate the stage with regard to astronavigational remote sensing, then, in the 90's of this century, using CCD cameras as remote sensing equipment for digital transmission type satellites will become the dominating force for astronavigational military reconnaissance and astronavigational natural resource sensing.

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